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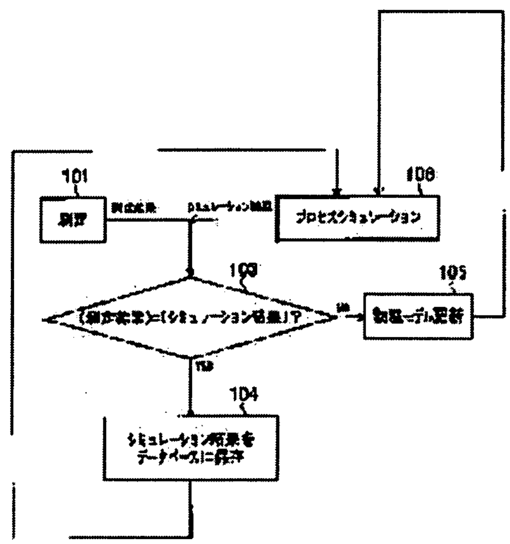
(54) MANUFACTURE OF SEMICONDUCTOR DEVICE, SIMULATION DEVICE AND METHOD, STORAGE MEDIUM RECORDING SIMULATION PROGRAM, AND STORAGE MEDIUM RECORDING WITH SIMULATION DATA RECORDED THEREIN

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a highly accurate simulation technique that is suited for the manufacturing process and a device structure of a semiconductor device.
SOLUTION: The result of a measurement (step 101) of a semiconductor device that has been manufactured actually is compared with that of simulation (step 106), and then a physical model for simulation is updated, if they do not match (step 105). Operations for updating the physical model are repeated until the measurement value accurately agrees with the simulation value, and the physical model, the measurement value, and the simulation value where they most accurately agree each other are stored in a database (step 104). Structural data and physical models, that are similar to a manufacturing process and structure data being recorded in the database thus constructed, and searched and the simulation (step 106) of the semiconductor device that is scheduled to be manufactured next is executed.



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CLAIMS

[Claim(s)]
[Claim 1] The manufacture approach of the semiconductor device which consists of each following step.
(b) Use the result of the step (b) this simulation which carries out simulation of the 1st semiconductor device with reference to a database. the step (Ha) which manufactures said 1st semiconductor device actually -- either [at least] the structure of said 1st semiconductor device or a property being measured, and by the step (d) this comparison which compares this measurement result with the result of said simulation With reference to the database with which the contents were rewritten by the additional step (e) this preservation which carries out additional preservation of the result of said simulation at said database when coincidence of said measurement result and the result of said simulation is good, it is the step which carries out simulation of the 2nd semiconductor device. [Claim 2] The structure of the semiconductor device manufactured by this production process for every production process of a semiconductor device, and one [at least] measurement result of a property, The database holding the data which compared and obtained the simulation result used in order to manufacture this semiconductor device, The structure of a semiconductor device where manufacture is planned with reference to this database from now on using the physical selected model, impurity density distribution, and the simulation section that carries out simulation of at least one of electrical characteristics, By the simulation result and a measurement result comparison means to measure either [at least] the structure of an actual semiconductor device, or a property, and to compare this measurement result with the result of said simulation, and said comparison Simulation equipment which has at least a renewal means for simulation of a physical model to update a physical model to other physical models when there is no coincidence of said measurement result and the result of said simulation within the limits of predetermined [Claim 3] The simulation approach which consists of each following step.
(b) The result of the step (b) this simulation which carries out simulation of at least one of the structure of a semiconductor device, impurity density distribution, and electrical characteristics with reference to the contents of the database, When there is no coincidence by the step (Ha) this comparison which compares the structure of the semiconductor device manufactured actually and one [at least] measurement result of a property within fixed limits For a fitness case, coincidence by the step (d) aforementioned comparison which changes the conditions of said simulation and redoes said simulation is the step to which additional preservation of the result of said simulation is carried out at said database. [Claim 4] The record medium which recorded the simulation program which consists of each following step for operating simulation equipment.
(b) Search a database and use the step (b) this information on the extracted specification which extracts specific information. The structure of a semiconductor device, impurity density distribution, When there is no coincidence by the step (d) this comparison which compares the result of the step (Ha) this simulation which carries out simulation of at least one of electrical characteristics, the structure of an actual semiconductor device, and one [at least] measurement result of a property within fixed limits For a fitness case, coincidence by the step (e) aforementioned comparison which changes the conditions of said simulation and redoes said

simulation is the step to which additional preservation of the result of said simulation is carried out at said database. [Claim 5] The data searched and extracted are recorded in the case of simulation activation, and when the coincidence in the comparison with the result of said simulation and the measurement result of the property of an actual semiconductor device is good It is the record medium with which the result of said simulation recorded the database by which additional preservation is carried out on the contents. This database is recorded on a process database file and a device database file. Said process database file It is recorded on two or more production process sub files sorted for every production process. The production process sub file and said device database file of this plurality The record medium which recorded the data for simulation characterized by providing a record section and the input file record section for simulation at least as a result of said measurement result record section and said simulation, respectively.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the flow chart which shows processing of the process simulation accompanied by the precision verification concerning the gestalt of operation of the 1st of this invention.
[Drawing 2] It is the typical block diagram showing the process-simulation equipment which has a precision verification function concerning the gestalt of operation of the 1st of this invention.
[Drawing 3] It is the block diagram showing the outline of the process-simulation section concerning the gestalt of operation of the 1st of this invention.
[Drawing 4] The histogram of the operating frequency of the physical model concerning the gestalt of operation of the 1st of this invention is shown.
[Drawing 5] It is the flow chart which shows processing of the device simulation accompanied by the precision verification concerning the gestalt of operation of the 1st of this invention.
[Drawing 6] It is the typical block diagram showing the device simulation equipment which has a precision verification function concerning the gestalt of operation of the 1st of this invention.
[Drawing 7] It is the block diagram showing the outline of the device simulation section concerning the gestalt of operation of the 1st of this invention.
[Drawing 8] It is the flow chart which shows the construction approach of the database concerning the gestalt of operation of the 1st of this invention.
[Drawing 9] It is the typical block diagram showing the detail of the database structure concerning the gestalt of operation of the 2nd of this invention.
[Drawing 10] It is the typical block diagram showing the detail of the process dispersion database structure concerning the gestalt of operation of the 2nd of this invention.
[Drawing 11] It is a typical block diagram for explaining the process simulation concerning the gestalt of operation of the 3rd of this invention.
[Drawing 12] It is a typical block diagram for explaining the device simulation concerning the gestalt of operation of the 4th of this invention.
[Drawing 13] It is a flow chart for explaining the manufacture approach of the semiconductor device concerning the gestalt of operation of the 5th of this invention.
[Drawing 14] It is the bird's-eye view showing the appearance of the semi-conductor simulation

equipment of this invention.
[Description of Notations]
20 Process-Simulation Section
21, 61, 74, 94 Processing control section
22 Ion Grouting is Processing Means.
23 Oxidation Process Processing Means
24 Deposition Process Processing Means
25 Etching Process Processing Means
26 Diffusion Process Processing Means
31, 51, 71, 91 Input section
32, 52, 72, 92 Data storage section
33, 53, 73, 93 Program store section
34, 54, 79, 99 Output section
40 Device Simulation Section
62 Electrical Potential Difference / Current Setting Means
63 Component Property Count Means
70 Process-Simulation Equipment
76 96 A simulation result and measurement result comparison means
77 Renewal Means for Process Simulations of Physical Model
78 98,340 Database
80 Semi-conductor Simulation Equipment
81 Floppy Disk Drive
82 Optical Disk Drive
83 Floppy Disk
84 CD-ROM
85 ROM
86 Cassette Tape
90 Device Simulation Equipment
97 Renewal Means for Device Simulation of Physical Model
341 Process Database File
370 Device Database File
380 Process Dispersion Database File
381 Yield Data Subfile
382 Threshold Data Subfile
403 Retrieval Equipment

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacturing technology of semiconductor devices, such as LSI, especially precedes the concrete manufacture process of a semiconductor device, and relates to the record medium which stored the program for performing the simulation

technique of designing and evaluating the structure of a semiconductor device (device), an impurity consistency, electrical characteristics, etc., and this simulation technique and in which a computer readout is possible, the record medium which recorded the data for simulation, and the manufacture approach of the semiconductor device using these simulation techniques further.
[0002]
[Description of the Prior Art] With increase of the accumulation consistency of semiconductor integrated circuits, such as the latest LSI, the development cost increases rapidly and low-cost-izing of semiconductor devices, such as a semiconductor integrated circuit, and efficient-ization of development are called for. For this reason, simulation which has quantitive prediction capacity on the occasion of a design and development of semiconductor devices, such as a semiconductor integrated circuit, is performed, and reducing time amount, an ingredient, power, and efforts has been increasing importance increasingly. In a design and development of such a semiconductor device, two simulation techniques are mainly used. That is, a series of production processes of a semiconductor device are calculated based on a physical predetermined model, and it is used as a simulator with typical process simulator (process-simulation equipment) who decides beforehand the impurity in the semiconductor device which it is actually going to make, distribution of a defect, or the geometry of the component of the semiconductor device and device simulator (device simulation equipment) who calculates the electric property of a semiconductor device beforehand based on a physical predetermined model.
[0003] As an actual activity in development of LSI, selection and a design of an outline of device structure are first made to a predetermined property specification. And the process simulation for carrying out the process design for realizing device structure of this outline is made. This process simulation gives as an input each process conditions in a raw material, the manufacture procedure performed to it, and its manufacture procedure, and calculates the impurity distribution and the other component structures which are formed by that production process. Next, device simulation which acquires the electric property of the component is performed from the component structure acquired in this way and the exterior by considering the electric conditions impressed to a component as an input. It investigates whether it becomes the property of the request which the acquired property tends to make by device simulation, and if it is a desired property, the production process of a semiconductor device actual next will be begun. Here, since a component to make from the considered production process cannot be made when not becoming a desired property, the conditions of a production process are changed, or the procedure itself, such as sequence of a process, is changed, and a process simulation and device simulation which uses the result of this process simulation as input data are performed again. Repeatedly, a line determines the manufacture approach of a semiconductor device and actually manufactures a desired semiconductor device until the production process of a component which has the property of a request of the above activity is obtained.
[0004] However, in this process device simulation, it roughly divides and there are 2 troubles. This trouble is explained below.
[0005] (Trouble 1) One is dependent on the precision of the physical model which the precision of a process simulation and device simulation uses in the simulator.
[0006] (b) Explain a process simulation first. In building the model into a simulator, since it is made based on the experimental result performed in some restricted conditions, it is necessary to notice the process model used for the usual process simulation about the applicability of a physical model. For example, the following effectiveness becomes important when carrying out the modeling of the acid chemically-modified degree. That is, it is a 2-dimensional oxidization

model for taking into consideration the effect of the BAZU peak of the oxygen tension dependency of - oxidation rate, - substrate impurity density dependence, - substrate side bearing dependency, or -LOCOS process etc. However, how for it to be difficult to take all of such effectiveness into consideration in fact, and to adopt a suitable physical model if needed is taken. In such a case, when the effectiveness which is not included in the adopted physical model becomes important, the precision of a process simulation will fall.

[0007] (b) On the other hand, the outline, the fluid model, and the particle model are known for device simulation. The fluid model is based on the mobility model. In this case, since a mobility model stops realizing and precision falls in a fluid model as the size of the component to manufacture becomes small, it is appropriate to apply a particle model. By the Boltzmann equation, since it is faithful, the particle model fits the analysis of a detailed device rather than the fluid model. However, computation time becomes large in order to carry out simulation of the movement of a huge number of each particles, when using a particle model. For example, since the number of the particles which should be dealt with increases as a device dimension increases, the device simulation by the particle model has not turned to a long channel device practically. Therefore, the method of using a particle model for the analysis of a short channel device using a fluid model is effective in the analysis of a long channel device. However, in the field which changes from a long channel device to a short channel device, there are no criteria which judge whether a fluid model should be used or a particle model should be used.

[0008] In such a field, if the approach of choosing the physical model optimal about count precision and computation time is used, it is efficient. Therefore, although a fluid model and a particle model will be used properly if needed, since there are no criteria which decide which physical model should be used, a particle model is applied to the field which can apply a fluid model, the computation time of a computer may be wasted, or with the application of a fluid model, count precision may be reduced to the field which should apply a particle model, and simulation with bad effectiveness may be performed.

[0009] Since the used physical model is not necessarily the optimal in respect of computation time and precision when performing a process simulation and device simulation as explained above, simulation with bad effectiveness is performed and there is a problem of falling the development effectiveness of a device.

[0010] (Trouble 2) On the other hand in the production process of an actual semiconductor device, the defect generated in connection with production processes, such as dispersion in the gate threshold electrical potential difference of the manufacture yield or MOSFET and dispersion of the current amplification factor hfe of a bipolar transistor (BJT), especially the production process of mass-production-method level influences the operating characteristic of a device greatly. Since it is based on the factor of a production process or a manufacturing installation proper, these cannot be predicted in the conventional process device simulation mentioned above. Therefore, even if it actually manufactures a semiconductor device by the manufacture approach determined by this process device simulation, desired electrical characteristics, a desired yield, etc. are not necessarily obtained. Moreover, dispersion in a gate threshold electrical potential difference of MOSFET which becomes a problem on mass-production-method level, dispersion of the current amplification factor hfe of BJT, or the manufacture yield cannot be judged if mass production method or the process which used to some extent a lot of semi-conductor wafers similar to this is not started after all. Therefore, the situation that un-arranging becomes clear in the statistics processing after consuming great time amount, a raw material, power, a labor cost, etc. occurs.

[0011]
[Problem(s) to be Solved by the Invention] Thus, since the criteria which determine the validity of the physical model built into simulation equipment in a conventional process simulation and device simulation are not necessarily clear, it applies, when [which should apply the physical model essentially] not coming out, and there is a problem on which the effectiveness of simulation is reduced and the development effectiveness of a device is reduced.
[0012] Moreover, dispersion or manufacture yields for every lot of the electrical characteristics of a semiconductor device and every wafer etc. had the trouble that it could not judge if the process using to some extent a lot of semi-conductor wafers is not actually started.
[0013] Even if it is a case with difficult selection of a physical model with which especially this invention poses a problem in the time of adoption of a new style device, new style structure, etc. in view of the above-mentioned trouble and which is adopted, it is making selection and modification of a physical model quickly and appropriately, and offering the manufacture approach of a short time and the semiconductor device which can manufacture and develop and improve a highly precise semi-conductor efficiently.
[0014] Other purposes of this invention are offering the manufacture approach of the semiconductor device which can estimate process dispersion of dispersion in the manufacture yield produced with mass production method, or a gate threshold electrical potential difference even if it does not actually manufacture a semiconductor device.
[0015] The selection and modification of a physical model to adopt are quick and appropriate, and the purpose of further others of this invention aims to let them offer the semi-conductor simulation equipment which can obtain an efficiently highly precise result.
[0016] The purpose of further others of this invention is offering the semi-conductor simulation equipment which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device.
[0017] The selection and modification of a physical model to adopt are quick and appropriate for the purpose of further others of this invention, and it is offering the efficient and highly precise semi-conductor simulation approach.
[0018] The purpose of further others of this invention is offering the semi-conductor simulation approach which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device.
[0019] The purpose of further others of this invention has short computation time, and it is offering the record medium which stored the semi-conductor simulation program which can obtain an efficiently highly precise result and in which computer reading is possible.
[0020] The purpose of further others of this invention is offering the record medium which stored the semi-conductor simulation program which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device and in which computer reading is possible.
[0021] The purpose of further others of this invention is offering the record medium which stored the database required for activation of a high speed and efficient and highly precise semi-conductor simulation and in which computer reading is possible.
[0022] The purpose of further others of this invention is offering the record medium which stored the database required for activation of the semi-conductor simulation which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device and in which computer reading is possible.
[0023]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the first description of this invention The result of this simulation is used. step; (b) which carries out simulation of the 1st semiconductor device which it is going to build from now on with reference to a (b) database -- The step which manufactures the 1st semiconductor device actually; (Ha) by the step; (d) comparison which measures either [at least] the structure of the 1st semiconductor device, or a property, and compares this measurement result with the result of simulation When coincidence of a measurement result and the result of simulation is good step; (e) which carries out additional preservation of the result of simulation at a database -- it is the manufacture approach of the semiconductor device which consists of a step which carries out simulation of the 2nd semiconductor device at least with reference to the new database with which the contents were rewritten by this additional preservation. Here, structure data, such as an impurity consistency of the substrate for every production process of semiconductor devices, such as MOSFET, and the junction depth of the source / drain field, and those process-simulation results and a measurement result and the device simulation result of those of electrical characteristics of the semiconductor device created through a series of production processes are included in a "database." Furthermore, it is desirable to include as a "database" the data of dispersion in processes, such as a manufacture yield generated with the semiconductor device manufacture and gate threshold electrical-potential-difference dispersion of MOSFET, etc. If the database of dispersion in processes, such as a manufacture yield and gate threshold electrical-potential-difference dispersion, is built, before actually manufacturing a semiconductor device, it will be because it becomes improvable [a production process]. That is, as compared with the process flow which carried out the flow (it is henceforth called a "process flow") of a series of production processes of a semiconductor device in the past, the production process of the most similar past is searched, and it has dispersion in the process in the searched production process, and it becomes possible to consider as the estimate of desired "dispersion of a process."
[0024] Especially the first description of this invention is suitable for a situation which wavers in decision which physical model two or more physical models are involved in simulation, among those is adopted. The manufacture approach of the semiconductor device concerning the first description of this invention in this case First, prepare two or more physical models, then a (b) database is referred to. The physical model which chose and chose [from] the specific physical model among two or more of these physical models is used. The result of this simulation is used. step; (b) which carries out simulation of the 1st semiconductor device which it is going to build from now on -- step; (d) which measures either [at least] the structure of the 1st semiconductor device of which step; (Ha) completion was done of manufacturing the 1st semiconductor device actually, or a property, and compares this measurement result with the result of simulation -- by this comparison When coincidence of a measurement result and the result of simulation is good The database with which the contents were rewritten by this additional preservation is referred to. step; which carries out additional preservation of the result of the physical selected model and simulation at a database, and (e) -- It is desirable to constitute from a step which carries out [from] simulation of the 2nd semiconductor device using the physical model which chose the specific physical model and was chosen among two or more physical models at least. In addition, the case where only a physical model with a certain specific single production process which forms the process flow exists in this case is not eliminated. This invention is applicable if involved in the physical model of the plurality of other production processes which constitute the process flow any one. Moreover, this invention is applicable, if device simulation is involved in two or more physical models even if it is the case where only a physical model with all the single

production processes that form the process flow exists. That is, this invention is applicable if the step which chooses a specific physical model and calculates [from] it in the simulation according to individual of either of them using the physical selected model among two or more physical models is contained in the set of the simulation according to two or more individuals. As for especially two or more physical models, it is desirable to save as a "database" in the form of the histogram according to the count (operating frequency) adopted as an optimal physics model etc. If the histogram of the optimal physics model is saved as a "database", at the time of next simulation, it can be adopted as simulation from a physical model with high operating frequency, and retrieval and selection of a physical model will become easy. And what is necessary is just to adopt the physical model saved as a physical model with high operating frequency next again with reference to a histogram, if coincidence of a measurement result and the result of simulation is bad. Thus, it becomes possible to obtain the result of simulation with a high precision quickly by updating the physical model to adopt one after another with reference to the histogram saved as a "database."

[0025] That is, since according to the first description of this invention a database can be built, the dependability of the physical model built in simulation equipment can be verified using this database and a physical model with the highest reliability can be chosen by comparing the electrical characteristics and the device simulation result of a semiconductor device of having compared the process-simulation result with the measurement result for every production process of a semiconductor device, and/or having completed, highly precise simulation becomes possible.

[0026] The measurement for every production process of a semiconductor device may use the TEG (test element group: Test Element Group) pattern arranged on a semi-conductor wafer, and may manufacture and measure the independent sample for process evaluation. The database of dispersion in a process is measured for every chip, every wafer, and every lot about each semiconductor device on a semiconductor chip, respectively, arranges the measured data and should just save them about the semiconductor device with which structure parameters differ, respectively.

[0027] The structure of a semiconductor device where the second description of this invention was manufactured in the past for every production process of a semiconductor device, and one [at least] measurement result of a property, The database holding the data which compared and obtained the simulation result used in order to manufacture the semiconductor device manufactured in this past, The structure of a semiconductor device where manufacture is planned with reference to this database from now on using the physical selected model, impurity density distribution, and the simulation section that carries out simulation of at least one of electrical characteristics, By the simulation result and a measurement result comparison means to measure either [at least] the structure of an actual semiconductor device, or a property, and to compare this measurement result with the result of simulation, and this comparison When there is no coincidence of a measurement result and the result of simulation within the limits of predetermined, it is simulation equipment which has at least a renewal means for simulation of a physical model to update a physical model to other physical models.

[0028] Here, in a "database", as the first description described, the data of process dispersion, such as a process data for every production process of a semiconductor device, those process-simulation results and the measurement result of the electrical characteristics of the semiconductor device created through the process flow, its device simulation result and a manufacture yield generated with the semiconductor device manufacture, and gate threshold

electrical-potential-difference dispersion, etc. are saved. Furthermore, two or more physical models may be arranged and saved in this database. For example, two or more physical models may be saved in a database in the form of the histogram according to the count (operating frequency) adopted as an optimal physics model etc. When saving the histogram of the optimal physics model in a database, with reference to the contents of this database, the selection circuitry which chooses [from] a specific physical model automatically among two or more physical models may be added further.

[0029] The process flow of a semiconductor device is calculated based on a physical predetermined model, on the other hand, the process simulator who decides beforehand the impurity in the semiconductor device which it is actually going to make, distribution of a defect, or the geometry of the component of the semiconductor device, and the device simulator who calculates the electric property of a semiconductor device beforehand based on a physical predetermined model come out at least, and a certain thing of the simulation section in the second description of this invention is desirable.

[0030] The simulation equipment of the second description of this invention of the data storage section which stored predetermined data required for the input section which receives the input of the data from an operator, an instruction, etc., the output section which outputs a simulation result and a precision verification result, and simulation etc., the program store section which stored the simulation program etc. being provided further is natural.

[0031] That is, since it makes it easy to verify the dependability of the physical model used for simulation comparing the measurement result and simulation result of structure data for every production process of a semiconductor device, or by comparing the measurement result and simulation result of an electric property of a semiconductor device of having completed, and to choose a physical model with the highest reliability according to the second description of this invention, highly precise simulation becomes quickly possible.

[0032] The step to which the third description of this invention carries out simulation of at least one of the structure of a semiconductor device, impurity density distribution, and electrical characteristics with reference to the contents of the (b) database; The result of (b) simulation, The step which compares the structure of the semiconductor device manufactured actually, and one [at least] measurement result of a property; (Ha) when there is no coincidence by this comparison within fixed limits The step which changes the conditions of simulation and redoes simulation; when coincidence by (d) one side and comparison is good, it is the simulation approach of having at least the step which carries out additional preservation of the result of simulation at a database. In next simulation, simulation of at least one of the structure of a semiconductor device, impurity density distribution, and electrical characteristics will be carried out with reference to the newest database with which the contents were rewritten by this additional preservation.

[0033] Here, the data of the structure data for every production process of a semiconductor device which was explained in the first description, those process-simulation results and the created measurement result of the electrical characteristics of a semiconductor device, its device simulation result, and process dispersion etc. are contained in a "database." If the database of dispersion in a process is built, as compared with the process flow carried out in the past, the production process of the most similar past is searched, and it will have dispersion in the process in the searched production process, and it will become possible to consider as the estimate of desired "dispersion of a process." Thus, if the third description of this invention is used, before actually manufacturing a semiconductor device, it will become possible to predict process

dispersion beforehand. Thus, since process dispersion can be predicted beforehand, amelioration of a process design becomes easy.

[0034] Especially the third description of this invention is suitable for a situation which wavers in decision which physical model two or more physical models are involved in simulation, among those is adopted. First, the simulation approach concerning the third description of this invention in this case prepares two or more physical models, among two or more physical models, with reference to a database, chooses a specific physical model and should just carry out simulation of a semiconductor device from from using this physical selected model. And what is necessary is to change into another physical model and just to redo simulation, when the comparison with the result of simulation and the measurement result of the semiconductor device manufactured actually is carried out and there is no both coincidence within fixed limits. Moreover, what is necessary is to carry out additional preservation of the physical selected model with the result of simulation at a database, and just to rewrite the contents of the database, when coincidence is good. In addition, if the step which chooses a specific physical model and calculates [from] it in the simulation according to individual of either of them using the physical selected model among two or more physical models is contained in the set of the simulation according to two or more individuals, the above-mentioned approach is applicable. For example, this invention is applicable, if it is involved in the physical model of the plurality of other production processes any one even if it is the case where only a physical model with a certain specific single production process which forms the process flow exists. As for especially two or more physical models, it is desirable to save as contents of the database in the form of the histogram according to the count (operating frequency) adopted as simulation as an optimal physics model etc. If the histogram of the optimal physics model is saved as contents of the database, at the time of next simulation, it can be adopted as simulation from a physical model with high operating frequency, and retrieval and selection of a physical model will become easy. And what is necessary is just to adopt the physical model saved as a physical model with high operating frequency next again with reference to a histogram, if coincidence of a measurement result and the result of simulation is bad. Thus, it becomes possible to obtain the result of simulation with a high precision quickly by updating the physical model to adopt one after another with reference to the histogram saved as contents of the database.

[0035] The fourth description of this invention is the record medium which stored the program for performing the simulation approach stated in the third description using the simulation equipment stated in the second description and in which computer reading is possible. Namely, the third description of this invention searches a (b) database. The step which extracts specific information; The (b)-extracted specific information is used. The structure of a semiconductor device, impurity density distribution, step; (Ha) which carries out simulation of at least one of electrical characteristics -- step; (d) which compares the result of this simulation, the structure of an actual semiconductor device, and one [at least] measurement result of a property, when there is no coincidence by this comparison within fixed limits Coincidence by (e) one side and comparison The step which changes the conditions of simulation and redoes said simulation; a fitness case It is the record medium which stored the simulation program which consists of a step which carries out additional preservation of the result of simulation at a database at least and in which a computer readout is possible. Especially, as for the step of the above-mentioned (b), it is desirable to choose a specific physical model and to carry out simulation of a semiconductor device with reference to a database, from from using this physical selected model among two or more physical models. In this case, what is necessary is to change into another physical model

and just to redo simulation in the step of the above-mentioned (d), when there is no coincidence within fixed limits. Moreover, what is necessary is to carry out additional preservation of the physical selected model with the result of simulation at a database, and just to rewrite the contents of the database in the step of the above-mentioned (e), when coincidence is good. As for especially two or more physical models, it is desirable to constitute a program which is saved as contents of the database in the form of the histogram according to the count (operating frequency) adopted as simulation as an optimal physics model etc. In this case, if the program is constituted so that it may be adopted as simulation from a physical model with high operating frequency at the time of next simulation, retrieval and selection of a physical model will become easy.

[0036] Thus, simulation of this invention can be performed by saving the program for realizing the semi-conductor simulation approach stated in the third description at the record medium in which computer read is possible, and making this record medium read according to a computer system. Here, a record medium means the equipment which can record the program of the external memory equipment of a computer, semiconductor memory equipment, a magnetic disk drive, an optical disk unit, optical-magnetic disc equipment, a magnetic tape unit, etc. Specifically, a floppy disk, CD-ROM, an MO disk, a cassette tape, an open reel tape, etc. are contained.

[0037] Thus, efficient highly precise semi-conductor simulation is realizable with the record medium which stored the simulation program concerning the fourth description of this invention and in which computer reading is possible, controlling the processing control section of a computer. Moreover, since process dispersion generated in connection with an actual production process using the database stated in the above-mentioned first thru/or the third description can be predicted beforehand, it becomes possible to perform the improvement of a semiconductor device production process efficiently. Consequently, the development effectiveness of the detailed device which needs highly precise simulation improves. This database may also be further stored in the record medium in which this computer reading is possible.

[0038] The fifth description of this invention starts the record medium which recorded the data for simulation for performing the simulation approach stated in the third description using the simulation equipment stated in the second description. That is, the data searched and extracted are recorded in the case of simulation activation, when the coincidence in the comparison with the result of this simulation and the measurement result of the property of an actual semiconductor device is good, the result of simulation is the record medium which recorded the database by which additional preservation is carried out on those contents, and this database is recorded on the process database file and the device database file. The contents of this process database file are recorded on two or more production process sub files sorted for every production process. And these production process sub files and device database files are characterized by providing a record section and the input file record section for simulation at least as a result of a measurement result record section and simulation, respectively. [two or more] Here, a record medium means the equipment which can record databases, such as the external memory equipment of a computer, semiconductor memory equipment, a magnetic disk drive, an optical disk unit, optical-magnetic disc equipment, and a magnetic tape unit. Specifically, a floppy disk, CD-ROM, an MO disk, a cassette tape, an open reel tape, etc. are contained.

[0039] It is desirable to provide further especially the histogram record section which arranged two or more physical models, respectively inside two or more of these production process sub

files and a device database file. What is necessary is to carry out statistics processing of the count adopted at every simulation by each simulation as an "optimal physics model", and just to save as a database arranged in the form of [according to the operating frequency] the histogram. If the histogram of the optimal physics model is saved as contents of the database, at the time of next simulation, it can be adopted as simulation from a physical model with high operating frequency, and retrieval and selection of a physical model will become easy. And if coincidence of a measurement result and the result of simulation is bad, again with reference to a histogram, the physical model saved as a physical model with high operating frequency next is employable.

[0040] Moreover, as for the database of the fifth description of this invention, it is desirable to have a "database of process dispersion" file further. If the database of dispersion in a process is built, as compared with the process flow carried out in the past, the production process of the most similar past is searched, and it will have dispersion in the process in the searched production process, and it will become possible to consider as the estimate of desired "dispersion of a process." For example, what is necessary is just to sort the database file of process dispersion at the subfile of the yield data which saved the manufacture yield, and the subfile of threshold data which saved the gate threshold electrical potential difference in the case of MOSFET. What is necessary is just to sort the data of dispersion in a current amplification factor hfe, and dispersion of emitter injection efficiency as a subfile as a "process dispersion database" in BJT.

[0041]

[Embodiment of the Invention] (Gestalt of the 1st operation) In the gestalt of operation of the 1st of this invention, the process simulation and device simulation which are performed while verifying the precision of the physical model to adopt are explained. First, a process simulation is explained and device simulation is explained below.

[0042] [I. Process-simulation] drawing 1 shows the flow chart of the process simulation concerning the gestalt of operation of the 1st of this invention. In this process simulation, process-simulation equipment 70 with the precision verification function shown in drawing 2 is used. This process-simulation equipment 70 is equipment with a functional means to perform the precision verification approach of checking the precision of the physical model built into the process-simulation program, by comparing a process-simulation result with an actual measurement.

[0043] As mentioning later about equipment 70, the verification approach of the precision of this physical model is first explained using the flow chart shown in drawing 1 . First, a semiconductor device is manufactured according to a process flow, and the structure data is measured for every production process (step 101). The measurement for every production process of a semiconductor device may use the TEG pattern arranged on a semi-conductor wafer, may manufacture the independent sample for process evaluation, and may measure each. On the other hand, about each production process, a process simulation is carried out (step 106) and compared with the measured value (structure data) of the obtained actual semiconductor device (step 103). Subsequently, if a simulation result and the measured value of an actual semiconductor device are well in agreement, it supposes that the physical model used with this process simulation is adopted, and saves in a database with a simulation result (step 104). If the precision of a simulation result is bad, it will update to another physical model considered (step 105), a process simulation will be performed again (step 106), and it will compare with measured value again (step 103). Here, "measured value (structure data) of an actual semiconductor device" is the measured value of the diffusion depth, if it is the measured value of oxide film

[0044] More concretely, it takes like ion grouting for an example, and propriety decision of the selection of a physical model at the time of choosing [from] a specific physical model among two or more physical models is explained. It is as required as ion grouting to decide distribution of an impregnation impurity. As an approach for that, it roughly divides and there are three approaches corresponding to three physical models.
[0045] (a) A primary method (first physical model) is leading the function showing impregnation impurity distribution to the basis of a suitable assumption. For example, consideration of the diffusion to the longitudinal direction of an impregnation impurity expresses the impregnation impurity distribution C (x y) with the following formula.
[0046]
[Equation 1]

$$C(x,\ y) = \frac{C(x)}{2} \cdot erfc\left(\frac{a-y}{\sqrt{2}\Delta X}\right) \cdots\cdots\cdots (1)$$

Here, C (x) is impurity distribution of the depth direction of a single dimension, and erfc is **********. moreover -- although deltaX is the standard deviation of longitudinal direction dispersion and it is the magnitude of standard deviation deltaRp extent of the depth direction dispersion (projection range of the ion when carrying out an ion implantation) -- the ratio -- deltaX / deltaRp They are the acceleration energy of impregnation ion, and the function of an ion kind. That is, with ion with small mass, it is easy to be scattered from the silicon (Si) of a target atom on a longitudinal direction like boron (11B+). For example, with the practical acceleration energy of 40KeV thru/or 200KeV (s), they are deltaX / deltaRp of boron (11B+). It is about 1.25. On the other hand, like arsenic (75As+) or phosphorus (31P+), when the mass of impregnation ion is bigger than the mass of a silicon atom, the lateral amount of dispersion becomes less, and they are deltaX / deltaRp. A value is set to 0.7 and 0.87, respectively. In addition, a formula (1) is an example and it is needless to say that various analysis types are adopted under the suitable assumption for others.
[0047] According to this approach, impregnation impurity distribution can be easily searched for with various analytic functions, such as a formula (1). However, since it cannot apply when the assumption to which the analytic function was led is not realized, applicability becomes narrow.
[0048] (b) The second approach (second physical model) is an approach of transposing movement of an impregnation atom to a transportation problem, and solving the Boltzmann equation. The advantage of this approach is that the ion-implantation distribution to the cascade screen from which stopping power differs is also searched for correctly. Furthermore, it is also possible to search for the distribution of these atoms by which beat appearance was carried out by using the same Boltzmann transport equation also to the substrate atom begun to beat with impregnation ion. However, the fault of the count based on the Boltzmann transport equation is that memory and computation time become huge.
[0049] (c) The third approach (third physical model) is a Monte Carlo method. This approach generates a random number for each collision process of every, determines a relative position with the silicon atom of a target, i.e., an impact parameter, and calculates dispersion of impregnation ion under that value. According to this approach, the ion-implantation distribution through a complicated cascade screen is correctly calculable. However, in order to acquire highly precise distribution, it is necessary to calculate the orbit of many particles (impregnation ion), and computation time becomes huge.
[0050] Although count precision improves in order of the second and third approach (physical model) for a start among these three approaches (physical model), count becomes complicated gradually and computation time becomes longer. Therefore, difficult count is not usually carried out from the start, but a primary method is applied first. As already stated, the analysis type used by this primary method is not restricted to above-mentioned (1) type. If it is a suitable analysis type showing impregnation impurity distribution, other various analysis types are employable. What suits measured value most among these analyses types will be chosen. In a primary method, when precision does not improve, the second approach is used. The third approach is used if precision does not improve by the second approach. With such a procedure, the approach (physical model) of reproducing measured value with the most sufficient precision can be chosen.
[0051] What is necessary is here, just to perform a procedure with the same said of other production processes, although it took and explained to the example like ion grouting. Thus, if the most accurate physical model is chosen from from among two or more physical models, the process-simulation result and the used physical model which gives

this best precision will be saved in a database (step 104), and the contents of this database will be considered as the input of the precision verification about the following production process.

[0052] Such precision verification is performed about each production process of a series of semiconductor device production processes which the deposition process / etching process / ion grouting for manufacturing a semiconductor device become from a /oxidation process / diffusion process. Under the present circumstances, the most accurate physical model for process simulations is chosen from from among two or more physical models by each production process. For example, if it is the production process of MOSFET, it arranges in the database prepared about each production process of MOSFET for every parameters, such as the junction depth, such as a source field and a drain field, an impurity consistency of a substrate or an impurity consistency of a well, gate oxidization thickness, gate length, or gate width, and saves as structure data in it (step 104). Thus, the database built from the structure data which give the best precision calculated by process-simulation equipment is henceforth called a "process database." The physical model required to carry out the modeling of each production process is also stored in this database.

[0053] Next, the process-simulation equipment 70 of this invention shown in drawing 2 is explained. The input section 71 which this process-simulation equipment 70 is equipment with the precision verification function of the adopted physical model, and receives the input of the data from an operator, an instruction, etc., The processing control section 74 equipped with the functional means for performing a series of precision verification approaches shown in the flow chart of drawing 1 , The output section 79 which outputs a precision verification result, and the data storage section 72 which stored predetermined data required for a semiconductor device manufacture process etc., The program store section 73 which stored the process-simulation program accompanied by the precision verification according to the flow chart of drawing 1 etc., It consists of databases 78 which have saved various kinds of physical models, the simulation result, the measurement result of an actual semiconductor device, etc. at least.

[0054] Here, as a functional means to perform a series of precision verification approaches, there are the process-simulation section 20, a simulation result and a measurement result comparison means 76, and renewal means of physical model 77 grade for process simulations, and the processing control section 74 possesses these functional means 20, 76, and 77 at least. A simulation result and the measurement result comparison means 76 verify the precision of the physical model which the current process-simulation section 20 is performing by comparing the measurement result saved in the database 78 with the simulation result searched for in the process-simulation section 20. If precision has not reached a desired value, with the renewal means 77 for process simulations of a physical model, a physical model is chosen from a database 78, the physical model of the source file of the process simulation memorized by the program store section 73 using a certain edit editor is updated, and a process simulation is performed again. Such an activity is repeated until the highly precise result is obtained. In this way, the obtained structure data are saved in a database 78 through the output section 79.

[0055] Drawing 3 is the block diagram showing the functional configuration of the process-simulation section 20 used for the process-simulation equipment 70 shown in drawing 2 . This process-simulation section 20 has the function which carries out simulation of the production process of a series of semiconductor devices with which it consists of the same configuration as conventional process-simulation equipment, and etching processes, such as deposition processes, such as CVD, and RIE, and ion grouting consist of an oxidation process, a diffusion process, etc., and the function which displays the component configuration which it is as a result of [this] simulation, impurities-in-a-semiconductor distribution, etc. on the output section. That is, as shown in drawing 3 , the process-simulation section 20 consists of the input section 31 which receives the input of the data from an operator, an instruction, etc., the processing control section 21 equipped with the functional means which carries out simulation of the process flow, the output section 34 which outputs a simulation result, the data-storage section 32 which stored predetermined data required for the semiconductor-device manufacture process as input data etc., and the program store section 33 which stored programs, such as a simulation program, at least.

[0056] Here, it considers as the functional means which carries out simulation of the process flow of the processing control section 21, and has the processing means 22, the degree [acid chemically-modified] processing means 23, the deposition process processing means 24, the etching process processing means 25, and the diffusion process processing means 26 grade for ion grouting at least. For example, as for the deposition process processing means 24, low temperature CVD, an elevated temperature CVD, epitaxial growth, vacuum deposition, sputtering, etc. are included. It is undoubted that wet etching is also included as an etching process processing means 25 besides dry etching, such as RIE, ECR ion etching, and ion milling, photo excited etching. The input section 31 consists of a keyboard, a mouse, a

light pen, or a floppy disk drive unit. The processing control section 21 constitutes some central processing units (CPU) of the usual computer system. The data storage section 32 and the program store section 33 may be constituted from main storage inside CPU, and may consist of storage, such as the semi-conductor ROM connected to this CPU, Semi-conductor RAM, and a magnetic disk. Moreover, the output section 34 is constituted by a display unit, printer equipment, etc.

[0057] The input data of each processing performed by the processing control section 21 shown in drawing 3 is stored in the data storage section 32, and program instruction is memorized by the program store section 33. And while such input data and program instruction are read into CPU if needed and data processing is performed by the processing control section 21 inside CPU, data, such as numerical information generated at each process, are stored in the data storage sections 32, such as RAM and a magnetic disk.

[0058] In addition, in drawing 2 , the input section 71 consists of a keyboard, a mouse, a light pen, or a floppy disk drive unit. The processing control section 74, the data storage section 72, and the program store section 73 consist of usual computer systems containing storage, such as CPU and the semi-conductor ROM connected to this CPU, Semi-conductor RAM, and a magnetic disk. Moreover, the output section 79 is constituted by a display unit, printer equipment, etc. ** et al. -- ** -- the input section 31 of the process-simulation section 20 shown in drawing 3 , the data storage section 32, the program store section 33 and the output section 34, and common hardware may be used for the input section 71, the data storage section 72, the program store section 73, and the output section 79, and respectively independent hardware may be used for them.

[0059] The program for performing a series of precision verification approaches shown in drawing 1 may be saved at the storage in which computer reading is possible. This storage can be made to be able to read according to a computer system, it can store in the program store section 73, and the process-simulation approach which performs this program by the processing control section 74, and starts the gestalt of operation of the 1st of this invention can also be realized. Here, with a record medium, the equipment which can record the program of the external memory equipment of a computer, semiconductor memory equipment, a magnetic disk drive, an optical disk unit, optical-magnetic disc equipment, a magnetic tape unit, etc. is contained. Moreover, the database for performing a series of precision verification processings shown in drawing 1 may also be saved at the storage in which these computer reading is possible.

[0060] By the way, a physical model with the highest operating frequency can be chosen under the same process conditions using the database created by doing in this way. For example, if it is the production process of nMOSFET, the database mentioned above shall be created about n kinds of nMOSFET(s) from which a structure parameter differs, respectively. When its attention is paid to a production process (m) about each nMOSFET, the physical model which is a certain nMOSFET is chosen, and another physical model is chosen as highly precise physical model in another nMOSFET. Then, when its attention is paid to a production process (m), the physical model for process simulations is packed as a histogram like drawing 4 in order of operating frequency. In drawing 4 , it is the case where the physical model 1 is used by the highest frequency as a highly precise physical model about the production process (m). Therefore, if the physical model 1 is adopted about the production process in the case of manufacturing nMOSFET by which the structure parameter was similar to process-simulation equipment by referring to a histogram like drawing 4 (m), it is expected that the coincidence as measured value of the structure data when passing through an actual production process (m) will be good. What is necessary is to use the physical model 2 with operating frequency high subsequently for the physical model 1, and just to perform a precision verification means according to the histogram of drawing 4 , even if coincidence with measured value is not good. Thus, if the physical model is chosen in order according to the histogram of drawing 4 in the precision verification means, an accurate physical model can be chosen efficiently. Thus, the histogram of drawing 4 makes a precision verification means easy by setting in order in order with operating frequency high about each physical model.

[0061] [II. device simulation] drawing 5 shows the flow chart for performing device simulation concerning the gestalt of operation of the 1st of this invention. On the occasion of activation of this simulation, device simulation equipment 90 with the precision verification function shown in drawing 6 is used. The device simulation equipment 90 shown in drawing 6 is equipment which can check the precision and validity of a physical model which are included in the device simulation program by comparing the current-voltage characteristic acquired in device simulation with the current-voltage characteristic acquired by the observation. About device simulation equipment 90, it mentions later.

[0062] First, the precision verification approach which starts the gestalt of operation of the 1st of this invention with the

flow chart of drawing 5 is explained. First, the current and the voltage characteristic of the actual semiconductor device created according to the predetermined process flow are measured (step 201). On the other hand, device simulation is performed by considering the structure data called for by the process simulation (step 208) as an input, and a current and the voltage characteristic are searched for (step 206). Subsequently, a device simulation result is compared with a measurement result (step 203). If the precision of the current-voltage characteristic acquired in device simulation is bad, it will update to another physical model considered (step 205), device simulation (step 206) will be performed again, and it will compare with an actual measurement (step 203).

[0063] Here, it roughly divides into the physical model used in device simulation, and there are a fluid model and a particle model. Within the limit of a fluid model, there are a energy transport model and a quantum transportation model in consideration of the quantum effectiveness. Under appropriate conditions, a fluid model should just perform precision verification using these energy transport models and quantum transportation models. Since a premised mobility [model / fluid] model stops realizing if the gate length of MOSFET and the base width of face of BJT become small, it becomes impossible however, to use a fluid model. In such a case, a particle model is needed. A particle model tends to make each particle exercise in the environment described by the equation using a Monte Carlo method, and tends to acquire the solution of the transport equation of Boltzmann by taking its time amount and ensemble average. However, compared with a fluid model, computation time is [the ******** of a particle model] a fault. Therefore, as for the device simulation on the basis of a particle model, precision becomes low if device simulation on the basis of a particle model and device simulation on the basis of a fluid model are performed by the same computation time. Since the boundary line which should shift to a particle model is not clear from a fluid model in fact, usually simulation by the fluid model with simple count is performed first. That is, after performing simulation by the fluid model, the comparison with a measurement result is carried out, the precision of a fluid model is checked, and it is thought rational to judge whether a particle model should be used.

[0064] A process as shown in the flow chart of drawing 5 is repeated, and the most accurate physical model is chosen to device simulation (step 206). It saves in a database by making into "device data" carrier distribution of the potential, electric field and current distribution in a semiconductor device acquired in the device simulation which adopted the physical model which gives this best precision, an electron, an electron hole, etc., etc., or the current-voltage characteristic (step 204). Moreover, the histogram which arranged the adopted physical model in order with high operating frequency like the case of a process simulation is created, and it saves in a database (step 204).

[0065] Device simulation shown in the flow chart of drawing 5 is performed using the device simulation equipment 90 shown in drawing 6 . Namely, the device simulation equipment 90 concerning the gestalt of operation of the 1st of this invention The processing control section 94 equipped with a functional means to perform a series of precision verification approaches indicated to be the input sections 91 which receive the input of the data from an operator, an instruction, etc. to the flow chart of drawing 5 , The output section 99 which outputs a simulation result, and the data storage section 92 which stored predetermined data required for the analysis of the property of a semiconductor device etc., It consists of databases 98 which have saved the program store section 93 which stored a series of programs, device simulation programs, etc. of the precision verification approach which were shown in the flow chart of drawing 5 , a measurement result required in order to perform the precision verification approach, etc. at least.

[0066] Here, as a functional means to perform a series of precision verification approaches of the processing control section 94, there are the device simulation section 40, a simulation result and a measurement result comparison means 96, and renewal means of physical model 97 grade for device simulation, and the processing control section 94 possesses these functional means 40, 96, and 97 at least. A simulation result and the measurement result comparison means 96 verify the precision of the physical model built into the device simulation section 40 by comparing the measurement result saved in the database 98 with the simulation result searched for in the device simulation section 40. If precision has not reached a desired value, with the renewal means 97 for device simulation of a physical model, a physical model is chosen from a database 98, the physical model of the source file of the device simulation memorized by the program store section 93 using a certain edit editor is updated, and device simulation is performed again. Such an activity is repeated until the highly precise result is obtained. In this way, the acquired electrical characteristics are saved in a database 98 through the output section 99.

[0067] The device simulation section 40 has the function which displays carrier distribution of the potential, the electric field and the current distribution in the function which has the function of inputting results, such as the component structure acquired with the process simulation to a predetermined process flow, and impurity distribution, sets up

electric boundary condition, such as applied voltage and a current, to the structure which inputted, and carries out the simulation of the electrical characteristics of a component, and the semiconductor device which are obtained as a result, an electron, an electron hole, etc. etc., the current-voltage characteristic, on the output section. That is, as shown in drawing 7 , this device simulation section 40 consists of the input section 51 which receives the input of the data from an operator, an instruction, etc., the processing control section 61 which carries out simulation of the electrical characteristics of a semiconductor device, the output section 54 which outputs a simulation result, the data storage section 52 which stored predetermined data required for the analysis of the property of a semiconductor device etc., and the program store section 53 which stored the device simulation program etc. at least. The processing control section 61 has at least the electrical potential difference / current setting means 62, and the component property count means 63 of setting up terminal voltage or current conditions. In drawing 7 , the input section 51 consists of a keyboard, a mouse, a light pen, or a floppy disk drive unit. The processing control section 61, the data storage section 52, and the program store section 53 consist of usual computer systems containing storage, such as CPU and the semi-conductor ROM connected to this CPU, Semi-conductor RAM, and a magnetic disk. Moreover, the output section 54 is constituted by a display unit, printer equipment, etc.

[0068] In addition, in drawing 6 , the input section 91 consists of a keyboard, a mouse, a light pen, or a floppy disk drive unit. The processing control section 94, the data storage section 92, and the program store section 93 consist of usual computer systems containing storage, such as CPU and the semi-conductor ROM connected to this CPU, Semi-conductor RAM, and a magnetic disk. Moreover, the output section 99 is constituted by a display unit, printer equipment, etc. The input section 51 shown in drawing 7 , the data storage section 52, the program store section 53 and the output section 54, and common hardware may be used for these input sections 91, the data storage section 92, the program store section 93, and the output section 99, and respectively independent hardware may be used for them.

[0069] The program for performing a series of precision verification approaches shown in drawing 5 may be saved at the storage in which computer reading is possible. This storage can be made to be able to read according to a computer system, it can store in the program store section 93, and the device simulation approach which performs this program by the processing control section 94, and starts the gestalt of operation of the 1st of this invention can also be realized. Here, with a record medium, the equipment which can record the program of the external memory equipment of a computer, semiconductor memory equipment, a magnetic disk drive, an optical disk unit, optical-magnetic disc equipment, a magnetic tape unit, etc. is contained.

[0070] the process database [in / in drawing 8 / the gestalt of the 1st operation] 1, the process database 2, the process database 3, and ...... it is the flow chart which shows how the process database m and a device database are built. a semiconductor device, for example, nMOSFET, -- a production process 1, a production process 2, a production process 3, and ..... it is assumed that it consists of a production process m. That is, a deposition process / etching process / ion grouting performs each production process 1, 2, and 3, such as a /oxidation process / diffusion process, ..., m (step 311 (1), step 311 (2), step 311 (3), ..., step 331 (m)). And measurement 1, 2, and 3, ..., m are performed about each production process 1, 2, and 3, ..., m (step 312 (1), step 312 (2), step 312 (3), ..., step 312 (m)), for example, it asks for the junction depth, such as a source field and a drain field, the impurity consistency of a substrate or the impurity consistency of a well, gate oxidation thickness, gate length, or gate width. Furthermore, these results are saved at the process databases 1, 2, and 3, ..., m. On the other hand, each production process 1, a production process 2, a production process 3, ... The process simulation 1 corresponding to a production process m, a process simulation 2, a process simulation 3, ... A process simulation m is performed. Each simulation result, the process database 1 and the process database 2, the process database 3, ... the measurement result saved in the process database m is compared according to the flow chart shown in drawing 1 , the precision of a physical model is verified, and precision verification for process simulations is performed (step 331 (1), step 331 (2), and step 331 (3) --) ....., step 331 (m). And about each production process, the most accurate physical model for process simulations is chosen, and the structure data 1, 2, and 3, ..., m are saved at each process database 1, 2, and 3, ..., m. If it is the production process of MOSFET, data, such as the junction depth, such as a source field and a drain field, an impurity consistency of a substrate or an impurity consistency of a well, gate oxidization thickness, gate length, or gate width, will be arranged for every parameter, and will be saved as structure data. The optimal physical model for carrying out the modeling of each production process is also stored in the databases 1, 2, and 3 of this process, ..., m. Furthermore, device simulation is performed to each process databases 1, 2, and 3, ..., m using the saved structure data 1, 2, and 3, ..., m. And according to the flow chart of drawing 5 , a device simulation result is compared with a measurement result, and a series of precision verification

for device simulation is performed (step 333). The electrical characteristics repeatedly acquired as a result in this precision verification for device simulation until the highly precise result was obtained are saved at a device database 370. The optimal physical model for carrying out the modeling of the electrical characteristics of the target semiconductor device is also stored in this device database 370.
[0071] What is necessary is just to perform the precision verification for process simulations (step 331 (1), step 331 (2), step 331 (3), ..., step 33 (m)) and the precision verification for device simulation (step 333) which were shown in drawing 8 using the device simulation equipment 90 shown in the process-simulation equipment 70 and drawing 6 which are shown in drawing 2 . In this case, it can be understood as the precision verification equipment for process simulations being built in process-simulation equipment 70, and the precision verification equipment for device simulation being built in device simulation equipment 90. However, the precision verification equipment for process simulations and the precision verification equipment for device simulation may be arranged to the exterior of usual process-simulation equipment (former) and device simulation equipment, and this usual process-simulation equipment and device simulation equipment, and a configuration that is made to link are sufficient as them.
[0072] Moreover, the preservation to the database of measurement data has two kinds of an approach which save measurement data in a database via a network by tying with a network the approach and - measuring device which save measurement data in a database, and a database by saving - measurement data at a certain record medium, and reading the record medium. Here, the external memory equipment of a computer, semiconductor memory equipment, a magnetic disk drive, an optical disk unit, optical-magnetic disc equipment, a magnetic tape unit, etc. correspond with "a certain record medium." What is necessary is just to more specifically use the floppy disk which can record such measurement data, CD-ROM, an MO disk, a cassette tape, an open reel tape, etc.
[0073] (Gestalt of the 2nd operation) Drawing 9 is the typical block diagram showing the database structure used for the simulation of the semiconductor device concerning the gestalt of operation of the 2nd of this invention. Here, MOSFET is taken up and explained as an example of a semiconductor device. That is, in the gestalt of operation of the 2nd of this invention, how to save in a database the manufacture yield of MOSFET manufactured based on the predetermined process flow and dispersion of the gate threshold electrical potential difference of this MOSFET is explained.
[0074] Usually, serially, using a contraction projection aligner (stepper) etc., MOSFET is a step-and-repeat method, and patterning is carried out to many exposure fields on a diameter 8 thru/or a 12 inches silicon wafer, and it is formed in each exposure field of 10mm thru/or 20mm angle as the so-called "chip." Therefore, according to the cause of a semiconductor-fabrication-machines-and-equipment proper, in MOSFET of each exposure field on every lot, every silicon wafer, and the silicon wafer of one sheet (chip field), a gate threshold electrical potential difference varies, or an excellent article and a defective are further generated to every exposure field (chip field). Generating with an excellent article and a defective produces the problem linking directly to the manufacture yield. Then, if dispersion in these manufacture yields or a gate threshold electrical potential difference can be predicted beforehand, even if it does not actually manufacture a semiconductor device, the improvement of a production process is possible, when manufacturing a certain MOSFET.
[0075] There are dispersion in a chip, dispersion in a wafer, dispersion in a lot, etc. as dispersion in a gate threshold electrical potential difference. With the gestalt of the 2nd operation, in order to enable such prediction, further, "manufacture yield data" and "the dispersion data of a gate threshold electrical potential difference" are arranged in the database explained with the gestalt of the 1st operation for every chip, every wafer, and every lot, and are saved in it about two or more MOSFETs (large number) from which a structure parameter differs, respectively. As long as there is need, data files, such as dispersion further between lots, dispersion for every equipment, and dispersion for every production works, may be added.
[0076] (1) Dispersion in a chip : here, decide the data about dispersion in a chip of a gate threshold electrical potential difference as follows.
[0077] (1a) Suppose that MOSFET of N individual is arranged to each chip field on a silicon wafer. First, its attention is paid to the chip j on Wafer k of a specific lot. A gate threshold electrical potential difference is measured about each MOSFET on this chip j. This is set with Aijk. i expresses i-th MOSFET arranged on the chip j of Wafer k. This measurement is performed about all MOSFETs on the chip j of Wafer k, and an average gate threshold electrical potential difference is computed. It asks for the gate threshold electrical potential difference <cAjk> of an average of the chip j on Wafer k as follows.

[0078]
[Equation 2]

$$<^{c}A_{jk}> = \frac{1}{N}\sum_{i}^{N} A_{ijk} \cdots\cdots\cdots (2)$$

(1b) Subsequently, ask for the standard deviation csigmajk of the gate threshold electrical potential difference of the chip j on Wafer k by the following formula using the gate threshold electrical potential difference of this average.
[0079]
[Equation 3]

$$^{c}\sigma_{jk}^{2} = \frac{1}{N}\sum_{i}^{N}\left(A_{ijk} - <^{c}A_{jk}>\right)^{2} \cdots\cdots\cdots (3)$$

(2) Dispersion in a wafer : decide the data about dispersion in a wafer of a gate threshold electrical potential difference as follows.
[0080] (2a) Suppose that there are M chip fields on a silicon wafer k. First, the gate threshold electrical potential difference Aijk is measured about each MOSFET arranged on each chip field on the specific silicon wafer k. And it asks for the gate threshold electrical potential difference <cAjk> of each average of each chip j on a silicon wafer k (j=1-M) using a formula (2). Then, the gate threshold electrical potential difference <wAk> of the average on a silicon wafer k is called for as follows.
[0081]
[Equation 4]

$$<^{w}A_{k}> = \frac{1}{M}\sum_{j}^{N} <^{c}A_{jk}> \cdots\cdots\cdots (4)$$

(2b) Subsequently, use the gate threshold electrical potential difference <wAk> of this average, and ask for the standard deviation wsigmak of the gate threshold electrical potential difference on a silicon wafer k by the following formula.
[0082]
[Equation 5]

$$^{w}\sigma_{k}^{2} = \frac{1}{M}\sum_{j}^{M}\left(<^{c}A_{jk}> - <^{w}A_{K}>\right)^{2} \cdots\cdots\cdots (5)$$

(3) Dispersion in a lot : decide the data about dispersion in a lot of a gate threshold electrical potential difference as follows.
[0083] (3a) Make the number of sheets of the silicon wafer of one lot into L sheets. The gate threshold electrical potential difference <wAk> of each average of all the silicon wafers k of a specific lot (k=1-L) is computed using a formula (4). If the gate threshold electrical potential difference <wAk> of this average is used, it can ask for the gate threshold electrical potential difference <LOTA> of an average of the target lot as follows.
[0084]
[Equation 6]

$$<^{LOT}A> = \frac{1}{L}\sum_{k}^{L} <^{w}A_{K}> \cdots\cdots\cdots (6)$$

(3c) Subsequently, ask for standard deviation LOT** ** of a gate threshold electrical potential difference by the following formula using the gate threshold electrical potential difference <LOTA> of this average.
[0085]
[Equation 7]

$$^{LOT}\sigma^{2} = \frac{1}{L}\sum_{k}^{L}\left(<^{w}A_{K}> - <^{LOT}A>\right)^{2} \cdots\cdots\cdots (7)$$

Let the gate threshold electrical potential difference Aijk of each MOSFET calculated as mentioned above, the gate threshold electrical potential difference <cAjk> of the average in each chip j and standard deviation csigmajk, the gate threshold electrical potential difference <wAk> of the average in each silicon wafer k and standard deviation wsigmak, the gate threshold electrical potential difference <LOTA> of the average in a lot, and standard deviation LOTsigma be data about a gate threshold electrical potential difference.
[0086] Moreover, let the rate of the defective when manufacturing MOSFET be a manufacture yield.
[0087] And the data (yield data) about the <data Aijk and cAjk> about dispersion in a gate threshold electrical potential difference (threshold data) for which carried out in this way and it asked, <wAk>, <LOTA>, csigmajk, wsigmak, LOTsigma, and the manufacture yield are saved in a database. In the simulation of MOSFET concerning the gestalt of operation of the 2nd of this invention, the threshold data and yield data which were manufactured according to the predetermined process flow, with which structure parameters differ, respectively and which were mentioned above about each of each MOSFET are saved. That is, in the gestalt of operation of the 2nd of this invention, the database which saved above-mentioned threshold data and yield data, and the process database and device database which were explained in the 1st example are doubled, and it considers as a database.
[0088] Thus, as for the data saved in the created database, it is desirable to be arranged so that it may be easy to search as systematically as possible. Then, a database is divided into some kinds of files as shown in drawing 9 .
[0089] (i) -- the production process 1 required in order that blindness in one eye may manufacture a certain MOSFET, a production process 2, a production process 3, and ..... it is the process database file 341 which the production process m was alike, respectively, and sorted and saved corresponding data etc. at every each production process 1, 2, and 3, ..., m. That is, as shown in drawing 9 , the process database file 341 is recorded on each production processes 1, 2, and 3, ..., two or more production process sub files 350 (1) sorted by every m, 350 (2), 350 (3), ..., 350 (m). Namely, two or more of these production process sub files 350 (1), 350 (2), 350 (3), ... 350 (m), respectively 2 The measurement result record section 351-1, 3, ... As a result of simulation, such as m and structure data, (an impurity consistency, oxide-film thickness, etc.) 2 A record section 352-1, 3, ... 2 m, the input file record section 353-1 for simulation, 3, It has at least ......, m, the histogram record section 354-1 that arranged the physical model for process simulations in order with high operating frequency about each production process further, 2 and 3, ..., m.
[0090] (ii) The second is the process dispersion database file 380 which consists of a yield data subfile 381 which saved the manufacture yield of MOSFET manufactured through these production processes, and a threshold data subfile 382 which saved the gate threshold electrical potential difference. The detailed structure of the process dispersion database file 380 is shown in drawing 10 . The threshold data subfile 382 is classified into database 382c which saved database 382a which saved dispersion in a chip of a gate threshold electrical potential difference <cAjk>, and csigmajk, dispersion in a wafer of a gate threshold electrical potential difference <wAk>, database 382b which saved wsigmak and dispersion in a lot of a gate threshold electrical potential difference <LOTA>, and LOTsigma. Moreover, the yield data subfile 381 is classified into database 381a for every chip, database 381b for every wafer, and database 381c for every lot.
[0091] The measurement result of having measured the component property of MOSFET that the third was manufactured through the process flow, (iii) The device simulation result of having performed as an input the structure data obtained by the process simulation, This input file for device simulation, the histogram which arranged the physical model for device simulation in order with high operating frequency further Respectively, it is the device database file 370 sorted and saved in the measurement result record section 371, the simulation result record section 372, the input file record section 373 for simulation, and the histogram record section 374.
[0092] Thus, another advantage of arranging a database to three files, the process database file 341, the process dispersion database file 380, and the device database file 370, is to be able to hold the inclination of dispersion in the process by the cause of the semiconductor-fabrication-machines-and-equipment proper currently used by each production process from the process dispersion database file 380. That is, if the data of the manufacture yield and gate threshold electrical-potential-difference dispersion are saved about as many kinds as possible of MOSFETs, there is an advantage which can predict the general inclination about dispersion in the process of semiconductor fabrication machines and equipment from these data.
[0093] For example, although it is expected that dispersion in a process actualizes so that gate length becomes small when MOSFET is assumed as a semiconductor device, it is difficult to decide whether such dispersion appears from the

gate length of how much concretely. However, in the database mentioned above, if the process dispersion database file 380 about each MOSFET is classified for every gate length of these MOSFETs, it can presume whether dispersion in a process actualizes from the gate length of how much. Of course, in order to attain such presumption, it cannot be overemphasized that it is necessary to fix a database about as many semiconductor devices as possible.

[0094] Although MOSFET was taken up and explained as an example of a semiconductor device above, as for the semiconductor device concerning the gestalt of operation of the 2nd of this invention, it is needless to say that it is restricted to neither MOSFET nor the insulated-gate mold transistor from which dispersion in a gate threshold electrical potential difference will become a problem. For example, as a semiconductor device concerning the gestalt of operation of the 2nd of this invention, junction type FET, MESFET, HEMT, BJT, a static induction transistor (SIT), IGBT, a thyristor, diode, etc. may be used. Photo detectors, such as light emitting devices, such as a light emitting diode (LED) and semiconductor laser, or a solar battery, and an avalanche photo-diode (APD), are sufficient. Furthermore, the integrated circuit which contains these discrete devices more than a kind at least is sufficient. And in BJT, it is possible to save the data of dispersion in a current amplification factor hfe and dispersion of emitter injection efficiency as a "process dispersion database." In SIT, it is possible to, use dispersion in the rate mu of voltage amplification etc. as the process dispersion database of this invention for example. Furthermore, in a miçrowave transistor and high frequency devices, such as a millimeter wave device, it is good also considering dispersion in an S parameter as a database. Namely, what is necessary is to adopt dispersion in a proper as each target semiconductor device as a process dispersion database, and just to build the database of a proper for every discrete device and every integrated circuit, respectively.

[0095] (Gestalt of the 3rd operation) Drawing 11 is a typical block diagram for explaining the process simulation concerning the gestalt of operation of the 3rd of this invention. When manufacturing a semiconductor device, the process flow is decided beforehand. If the factor which degrades "dispersion of a process", such as a manufacture yield expected from this process flow and dispersion of a gate threshold electrical potential difference, and other component properties at this time can be estimated quantitatively, even if it does not actually manufacture a semiconductor device, the improvement of a production process is possible. In order to advance the improvement of this production process efficiently, it is necessary to predict dispersion in a process as correctly as possible.

[0096] Therefore, as compared with the process flow which carried out the process flow of the semiconductor device currently planned in order to carry out current manufacture in the past, the production process of the most similar past is searched, and it has dispersion in the process in the searched production process, and considers as the estimate of "dispersion of a process" of a semiconductor device which is going to carry out current manufacture.

[0097] How process flows are compared poses a problem here. In the following explanation, MOSFET is taken up like the gestalt of the 2nd operation as an example of a semiconductor device.

[0098] Drawing 11 is drawing explaining the case where the process flows of MOSFET are compared.

[0099] (b) Input predetermined process conditions into the input section 31 of the process-simulation section 20 explained by drawing 3 first. And the junction depth of the source / drain field which performs a process simulation by the processing control section 21 of the process-simulation section 20, and is predicted from the inputted process conditions, the impurity consistency (or impurity consistency of a well) of a substrate, gate oxidization thickness, gate length, etc. are outputted as structure data.

[0100] (b) Subsequently, if these structure data are inputted into retrieval equipment 403, retrieval equipment 403 will search the process database of a database 340, and will search the structure data nearest to the inputted structure data. Retrieval of this structure data uses the approach explained below. namely, - MOSFET with the gate length nearest to the gate length of the structure data inputted first is searched. Let the group who consists of such an MOSFET be Group A.

[0101] - Search MOSFET which gives the gate oxidation thickness nearest to the oxide-film thickness of the structure data inputted in Group A subsequently. Let the group who consists of such an MOSFET be Group B.

[0102] - Search MOSFET with the impurity consistency of the substrate nearest to the impurity consistency of the substrate of the structure data inputted in Group B subsequently. Let the group who consists of such an MOSFET be Group C.

[0103] - Search MOSFET with the junction depth nearest to the junction depth of the source / drain field of the structure data inputted in Group C subsequently. Let the group who consists of such an MOSFET be Group D.

[0104] Thus, it is structure data most similar to the structure data which the called-for group D inputted. As the detailed

structure of the process dispersion database file 380 is shown in drawing 10 , the yield data subfile 381 and the threshold data subfile 382 are saved in the database 340 about each of MOSFET belonging to this group D. Therefore, retrieval equipment 403 chooses them from a database 340. Thus, although the searched data about the manufacture yield and gate threshold electrical-potential-difference dispersion may be different according to the class of each MOSFET in Group D, they give the near standard about process dispersion of the process flow which gives the inputted structure data.

[0105] Thus, according to the 3rd example of this invention, process dispersion can be predicted, without making a semiconductor device as an experiment. Moreover, the production process according to individual which is carrying out rate-limiting [of those process dispersion] can be extracted and examined. Therefore, it becomes easy to improve a production process so that the manufacture yield may improve. However, for that purpose, the comparison of process flows must be performed with a sufficient precision. Therefore, it cannot be overemphasized that it is necessary perform the precision verification means mentioned above about as many production processes as possible, and to store structure data in a database.

[0106] It is the same as that of the gestalt of the 2nd operation that the integrated circuit containing discrete devices, such as junction type FET, MESFET, HEMT, and BJT, SIT, or these is sufficient as a semiconductor device concerning the gestalt of operation of the 3rd of this invention.

[0107] (Gestalt of the 4th operation) Drawing 12 is a typical block diagram for explaining the device simulation concerning the gestalt of operation of the 4th of this invention. The gestalt of the 4th operation explains the configuration of the device simulation equipment for performing device simulation efficiently. First, conditions required for the process flow of the target semiconductor device are inputted into the input section of the process-simulation section 20, and a process simulation is performed in it. Subsequently, the structure data obtained with this process simulation are inputted into the retrieval equipment 403 shown in drawing 12 . That is, as the gestalt of the 3rd operation explained, the structure data nearest to the structure data inputted by searching a database 340 are chosen. As detailed structure is shown in drawing 9 , the device database file 370 corresponding to the process database file 341 is accumulated in the database 340. Therefore, the input file which used the structure data for the device simulation considered as the input is chosen from the input file record section 373 for simulation of the device database file 370 corresponding to selected structure data. The selected input file is inputted into the input section 51 of the device simulation section 40 explained by drawing 7 .

[0108] Since accompany this input file and it is not necessarily written to the desired purpose, it is necessary to rewrite according to the purpose. However, the effort which creates an input file compared with the case where all input files are created by themselves is mitigated sharply. Thus, the created input file is inputted into the processing control section 61 of the device simulation section 40, and device simulation is performed.

[0109] (Gestalt of the 5th operation) Next, the manufacture approach of the semiconductor device concerning the gestalt of operation of the 5th of this invention is explained. The gestalt of operation of the 5th of this this invention is related with the technique of performing LSI development with high precision and quickly.

[0110] The manufacture approach of the semiconductor device applied to the gestalt of operation of the 5th of this invention according to the flow chart which shows the procedure of the LSI development shown in drawing 13 is explained.

[0111] (b) Selection and a design of an outline of device structure are first made to predetermined property and specification. And the process simulation for carrying out the process design for realizing device structure of this outline is made (step 901). This process simulation gives as an input each process conditions in a raw material, the manufacture procedure performed to it, and its manufacture procedure, and calculates structure data formed by that production process, such as impurity distribution and other component structures.

[0112] (b) Next, as a result of step 901, if it is the production process of MOSFET, structure data, such as the junction depth, such as a source field and a drain field, an impurity consistency of a substrate or an impurity consistency of a well, gate oxidization thickness, and gate length, will be extracted (step 902).

[0113] (c) Next, search a database (step 903) and extract similar structure data. With reference to this extract result, threshold dispersion data and yield data are extracted further (step 904).

[0114] (d) Judge [whether structure data, threshold dispersion data, and yield data have fallen within the range which gives a desired property and quality after that, and] (step 905). If structure data, threshold dispersion data, and yield data have not fallen within the request range, it progresses to step 906 and a production process is improved. New

process conditions are given as an input on the basis of this improved production process, and a process simulation is made again (step 901). On the other hand, if structure data, threshold dispersion data, and yield data have fallen within the request range, device simulation which acquires the electric property of the component will be performed by considering structure data and the electric conditions impressed to a component from the exterior as an input (step 907).

[0115] (e) Next, investigate whether it becomes the electrical characteristics of the request which the acquired electrical characteristics tend to make by this device simulation (step 908). If judged with their being desired electrical characteristics at step 908, the production process of an actual semiconductor device will be begun (step 909). However, if judged with not becoming desired electrical characteristics, since a component to make from the considered production process cannot be made from step 908, production processes, such as modification of the procedure itself, such as modification of the conditions of a production process and sequence of a process, are improved (step 906). And a process simulation (step 901) and device simulation which uses the result of this process simulation as input data are performed again (step 907). If a line is success repeatedly until it is judged with having the electrical characteristics of a request of the above activity at step 908, a semiconductor device will actually be manufactured (step 909).

[0116] If the procedure shown in drawing 13 is followed, without actually manufacturing a semiconductor device, the error and incompleteness of a design will be discovered beforehand and the design and development of LSI of them will be attained efficiently. According to the manufacture approach of the semiconductor device concerning especially the gestalt of operation of the 5th of this invention, before actually manufacturing, "dispersion of a process", such as a manufacture yield and dispersion of a gate threshold electrical potential difference, can be estimated qualitatively. Furthermore, the factor which degrades other component properties can be estimated qualitatively. Therefore, since it is possible to omit a useless (or more) prototype, the cost concerning the turn around time of development or a prototype can be reduced.

[0117] (Gestalt of other operations) As mentioned above, although the gestalt of the 1st thru/or the 5th operation indicated this invention, if this invention is limited, he should not understand the statement and the drawing which make a part of this indication. The gestalt, example, and employment technique of various alternative implementation will become clear to this contractor from this indication.

[0118] For example, in drawing 2 or drawing 7 , although the typical configuration of the process-simulation equipment possessing the precision verification means of this invention and device simulation equipment was shown as an example, these configurations can be changed suitably. That is, the configuration that the precision verification equipment for process simulations and the precision verification equipment for device simulation are built in process-simulation equipment or device simulation equipment is used, the configuration which it is arranged to the exterior of usual process-simulation equipment (former) and device simulation equipment, and makes link mutually is sufficient as the precision verification equipment for process simulations, and the precision verification equipment for device simulation, and various deformation of these mixed gestalten etc. is still more possible.

[0119] Drawing 14 is the bird's-eye view showing a general view of semi-conductor simulation equipment which realized the process-simulation equipment, the device simulation equipment, and the database possessing the precision verification means mentioned above by the same hardware. The body of this semi-conductor simulation equipment 80 contains the process-simulation section, the device simulation section, a simulation result and a measurement result comparison means, the renewal means for process simulations of a physical model, a database, etc., and possesses the floppy disk drive unit (floppy disk drive) 81 and the optical disk unit (optical disk drive) 82 further. The program stored in these record media is installable in a system by inserting CD-ROM84 for a floppy disk 83 from the insertion opening to the optical disk drive 82 again to a floppy disk drive 81, and performing predetermined read-out actuation. Moreover, ROM85 as a memory apparatus used for the game pack etc. and the cassette tape 86 as a magnetic tape unit can also be used by connecting predetermined drive equipment. A database may be made to record on these record media, and the outboard recorder only for databases may be formed further. In the gestalt of the 2nd operation, three kinds of database files, the process database file 341, the process dispersion database file 380, and the device database file 370, were shown. The histogram record section 354-1, 2 and 3, ... and m which arranged the physical model for simulation in order with high operating frequency, and 374 are contained in the process database file 341 and the device database file 370. However, in this invention, all these database files are not necessarily required. With the gestalt of the 1st operation, it is the example to which the process dispersion database file 380 was abbreviated from

from among the three above-mentioned kinds of database files. Moreover, with the gestalt of the 5th operation, they are the histogram 354-1, 2 and 3, ... and m which arranged the physical model for simulation in order with high operating frequency, and the example 374 is not clearly shown to be. Therefore, it should be understood as the ability of the contents of the database of this invention to be changed suitably.

[0120] With the gestalt of the 5th operation, neither selection of a physical model nor processing of updating is specified. However, it will be able to be easily understood that a physical predetermined model is chosen from two or more physical models, and it can update to the optimal model combining the gestalt of the 5th operation and the gestalt of the 1st operation, if you understand the technical thought of this invention. That is, the process simulation in step 901 shown in drawing 13 and the device simulation in step 907 may be constituted so that the physical model judged to be the optimal may be chosen from from among two or more physical models with reference to the histogram of the physical model built as a database. Creation of the histogram of this physical model performs precision verification which was explained with the gestalt of the 1st operation, and should just store the data about the physical model which gives the highly precise result. Namely, what is necessary is just to transform a flow chart so that the processing which compares the structure data and the simulation result of a semiconductor device which were actually manufactured at step 905 shown in drawing 13 , and compares the electrical characteristics and the simulation result of the semiconductor device actually manufactured at step 908 may be included. That is, what is necessary is just to continue the processing which stores data at every manufacture of a semiconductor device, as coincidence is judged to be good and the physical model finally adopted as simulation is added and saved at the histogram in a database at step 905 or step 908 which deformed. And what is necessary is to stand in a row with processing of an improvement of production processes, such as modification of modification of the conditions of a production process, the sequence of a process, etc., and just to transform a process flow at step 906, so that processing of modification of a physical model may be performed.

[0121] Thus, he should understand that this invention includes the gestalt of various operations which have not been indicated here etc. Therefore, this invention is limited by only the invention specification matter which starts an appropriate claim from this indication.

[0122]

[Effect of the Invention] As explained above, according to this invention, selection of the physical model to adopt and the manufacture approach of a semiconductor device that modification and an improvement of a semiconductor device production process can be performed quickly and easily are realizable. That is, more advantageous effectiveness is done so when the new design theories at the time of a design and development of a new style device etc. are required. For example, it has effectiveness remarkable in device simulation in case conversion of the physical model from a classic theory to the quantum mechanics which poses a problem in the design of the ballistic transistor and ideal type SIT with which detailed dimension-ization progressed, a tunnel impregnation mold transistor, etc. is required. Therefore, the effectiveness of research and development of the Pioneer Electronic invention-new style semiconductor device improves.

[0123] Moreover, since according to this invention "dispersion of a process", such as a manufacture yield, dispersion of a gate threshold electrical potential difference, etc. which become a problem on mass-production level, can be estimated even if it does not actually manufacture a semiconductor device, the manufacture approach of a short time and an efficient semiconductor device is realizable.

[0124] Furthermore, according to this invention, the semi-conductor simulation equipment which can obtain an efficiently highly precise result can be offered.

[0125] Furthermore, according to this invention, the semi-conductor simulation equipment which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device can be offered.

[0126] Furthermore, according to this invention, selection of a physical model, and modification and the improvement of a semiconductor device production process to adopt can be performed quickly and easily, and the semi-conductor simulation approach which can obtain a simulation result with a more high precision for a short time can be offered.

[0127] Furthermore, according to this invention, the semi-conductor simulation approach which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device can be offered.

[0128] Furthermore, according to this invention, the record medium which stored the semi-conductor simulation

program which can obtain an efficiently highly precise result and in which computer reading is possible can be offered.
[0129] Furthermore, according to this invention, the record medium which stored the semi-conductor simulation gram which can estimate the manufacture yield and process dispersion even if it does not actually manufacture a semiconductor device and in which computer reading is possible can be offered.
[0130] Furthermore, according to this invention, the record medium which stored the database required for activation of a high speed and efficient and highly precise semi-conductor simulation and in which computer reading is possible can be offered.
[0131] Furthermore, according to this invention, by offering the record medium which recorded - TABESU which consists of "dispersion in process" data which become a problem on mass-production level, such as a manufacture yield and dispersion of a gate threshold electrical potential difference, even if it does not actually manufacture a semiconductor device, it becomes possible in simulation to estimate these.

[Translation done.]